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DATACOMPUTER PROJECT
SEMI-ANNUAL TECHNICAL REPORT

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Abstract

During the present reporting period, the datacomputer system achieved its initial operating capability on the Arpanet, and a number of host sites began using the service. For the month of July, the number of weekly connections to the system averaged about 500.

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1. Overview

1.1 Review of Basic Concepts

The goal of the project continues to be the development of a shared, large-scale data storage utility, to serve the needs of the Arpanet community.

The system under development will make it possible to store within the network such files as the ETAC Weather File or the NMRO Seismic Data File, which are measured in hundreds of billions of bits, and to make arbitrarily selected parts of these files available within seconds to sites requesting the information. The system is also intended to be used as a centralized facility for archiving data, for sharing data among the various network hosts, and for providing inexpensive on-line storage to sites which need to supplement their local capability.

Logically, the system can be viewed as a closed box which is shared by multiple external processors, and which is accessed in a standard notation, "datalanguage" (see Fig. 1). The processors can request the system to store information, change information already stored in the system, and retrieve stored information. To cause the datacomputer to take action, the external processor sends a "request" expressed in data-language to the datacomputer, which then performs the desired data operations.

From the user's point of view the datacomputer is a remotely-located utility, accessed by telecommunications. It would be impractical to use such a utility if, whenever the user wanted to access or change any portion of his file, the entire file

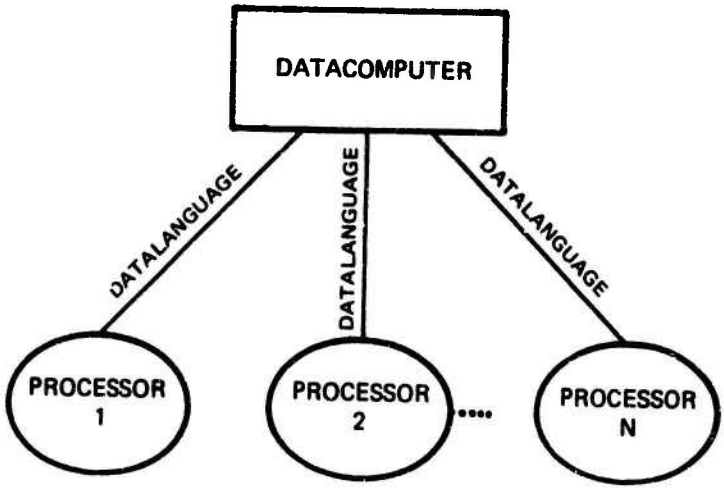

Figure 1. Logical View of Datacomputer

had to be transmitted to him. Accordingly, data management functions (information retrieval, file maintenance, backup, access security, creation of direct and inverse files, maintenance of file directories, etc.) are performed by the datacomputer system itself. The user sends a "request", which causes the proper functions to be executed at the datacomputer without requiring entire files to be shipped back and forth.

The hardware of the system is shown in overview in Fig. 2 and in greater detail in Fig. 3.

The program for the system processor handles the interactions with the network hosts and is designed to control up to three levels of storage: primary (core), secondary (disk), and tertiary mass storage. Currently, the CCA facility is operating with primary and secondary storage only, with the addition of tertiary storage planned for 1974. Installation of a tertiary storage module will leave datalanguage unchanged, and will therefore be imperceptible to users of the system (except insofar as it affects performance and the total storage capacity available for data).

In addition to using the dedicated equipment at CCA it is planned that datacomputer service will also make use of hardware resources located at NASA/Ames, using CCA software. The two sites will provide mutual backup for one another, thereby guarding against accidental loss of data and providing for satisfactory uptime of the overall service.

1.2 Status of Project

During the present reporting period, the datacomputer system achieved its initial operating capability on the Arpanet, and a number of host sites began using the service (see Section 4).

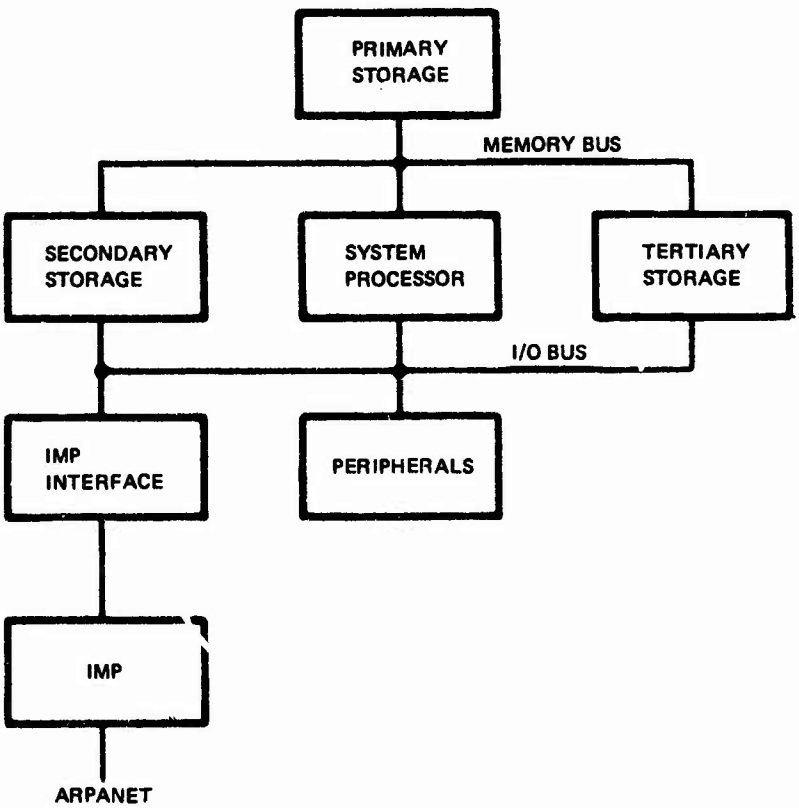

Figure 2. Hardware Overview of System

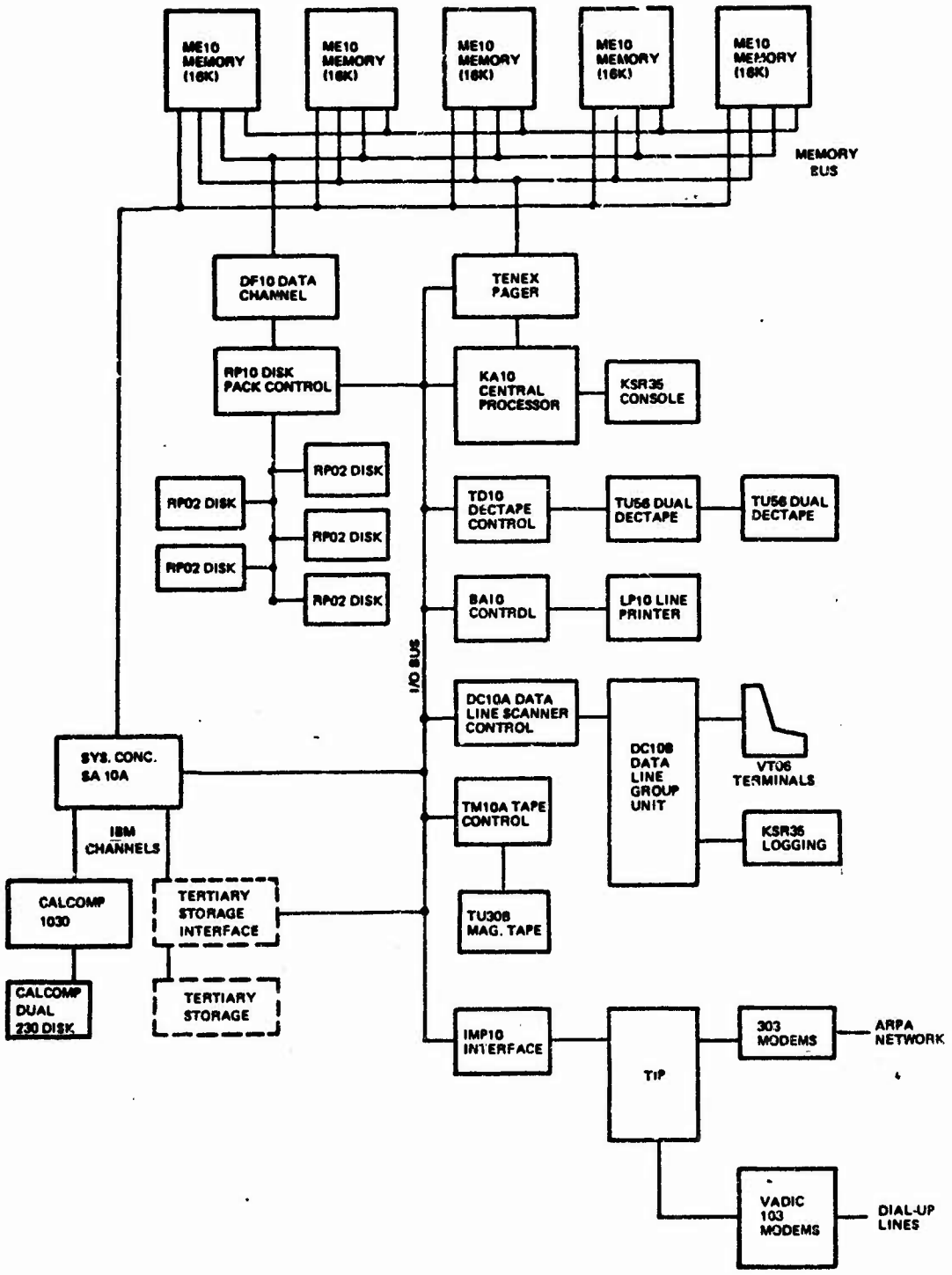

Figure 3. Hardware Block Diagram - CCA Installation
(Equipment in dashed outline is planned for 1974)

The service is based on Version 0/9, which was completed during the present period. (Previous versions of the system had been used only for demonstration and for internal CCA development purposes.) This version offers a (somewhat primitive) subset of the capabilities of the full datalanguage discussed in Working Paper No. 3.

The primary restriction of Version 0/9 is that elementary data types must be fixed-length ASCII strings. This restriction will be lifted in Version 0/10, scheduled for December 1973, which will provide a larger subset of the datalanguage capabilities.

Currently, only disk storage is available internally to the system. (Total disk storage is 9×10^8 bits, to be increased to 2.34×10^9 bits in the fourth quarter of 1973.) Plans call for the addition of tertiary storage in 1974. Since datalanguage is device-independent, these increases in storage capacity will not affect the user programs running on network hosts.

2. Design Activities

2.1 Datalanguage

A formal specification of datalanguage Version 0/9 was completed (see Appendix).

Progress was made in the specification of datalanguage for Version 0/10. This version, to be available over the network in December 1973, incorporates a data security facility at the directory level, more general data types and more general data structures. Specifically, there are arbitrary byte strings as well as character strings. Variable length as well as fixed length containers are permitted. In his data description, the user has some control over alignment of logical object and physical object boundaries. Physical byte sizes of 36, 32 and 8 are supported.

Based on the results with datalanguage to date, a major design iteration has begun. In the revised language, attention will be given to more general data structures, pointers, a syntax that is better for generation of language requests by programs, language extensibility, multiple descriptions of data, data integrity and privacy.

From the first language design period, the biggest changes in thinking have come from a better understanding of the data sharing problem on the network scale. In order for the network community to get the most out of the datacomputer facility, groups of users must be able to do two things they could not do well with the initial language: (1) develop their own systems of shared software that reside at the datacomputer, and

(2) have a description of the data that is independent of both the stored organization and the descriptions used by others.

That is, users must be able to have shared collections of access functions, data validation functions, and the like, specified in datalanguage, stored at the datacomputer, and associated with particular collections of data. Only in this way can distributed systems of user programs have a shared, centralized data management facility that is built around the datacomputer software but specialized for their requirements.

The independent description facility is needed so that the proper modularity can be designed into the global system involving datacomputer software, user requests, user files stored on the datacomputer, data descriptions, and a distributed system of user programs. It will be important to make components of such large systems as independent as possible. User programs should be independent of the stored data organization when this is feasible. Similarly, user programs not concerned with certain parts of the data collection should not have to know about them, both for protection of privacy and for simplicity in system reorganization.

Facilities that meet these requirements are being investigated. In addition, earlier work on the language is being reviewed and improvements are being considered.

2.2 Software System

The current design of the software system basically corresponds to the design documented in Working Paper No. 5 (February 29, 1972). Detailed design has continued as necessary, and is discussed in Section 3 as part of the implementation effort.

3. Software Implementation

During this period, implementation of Version 0/9 of the datacomputer was completed. The basic program structure is the same as in Version 0/8, but the new release incorporates additional capabilities. Version 0/9 is a multi-user system that allows simultaneous access to shared files. It includes minimal updating facilities, improved error diagnostics and recovery procedures, and standard initial connection protocol. The facilities are described in detail in "Specification for Datalanguage, Version 0/9", NIC 16446, June 6, 1973 (see Appendix of present report).

3.1 Request Handler

The Request Handler was developed for Version 0/8 along the lines of the system architecture outlined in Working Paper No. 5.

New in Version 0/9 is the ability to delete files and to append to files. Every open data container has a user-specified mode associated with it. The modes are: read, write and append. An assignment to a container whose mode is write replaces the data already in that container. If the mode is append, the new data is added to the end of the container. Parsing of the datalanguage and tuple generation is essentially the same in both cases. During execution, one tuple (the Open tuple) sets up a pointer to the beginning location of the new data. In the write case, the pointer points to the beginning of the container; in the append case, to the end. Except for the Open tuple, execution of write and append assignments is identical.

The datacomputer automatically updates the inversion when a file is updated. Other users are locked out until the update operation is complete.

Delete requests are passed immediately to a command executor (CO), which calls the services routine to remove the node from the directory. No parse tree is generated.

Users can mix inverted file keys and non-keys freely in expressions. Where possible, the datacomputer takes advantage of the inversion in evaluating the expression.

3.2 Services

Storage Manager

The storage manager now recognizes several kinds of devices: disk, special disk, and tape. Data structures have been developed for describing each device, and the address-mapping and storage allocation routines make use of these structures. This was done in preparation for adding a tertiary store as a new device.

I/O Manager

Standard initial connection protocol was implemented. Users can open secondary network connections for the transfer of data.

Directory System

Directory nodes can now be deleted.

The user's datalanguage description is stored in the directory. The user can access the description as necessary. He can also get a list of all nodes in the directory.

Supervisory Functions

The datacomputer runs under a monitor which allows for several users. These users share a database and can simultaneously access a file. To support this feature, all the code has been made re-entrant.

A module (OP) has been added to provide for communication with a system operator.

Messages have been divided into five categories: synchronization, informational, user error, circumstantial error, and datacomputer error. A code prefixed to each message indicates to the user program the category of each message. In some cases, the code uniquely identifies the message. These codes aid the user program in taking appropriate action.

Error recovery procedures have been added. Depending on the seriousness of the error, these range from restarting one user to bringing down the entire datacomputer system.

A dump/restore utility for datacomputer files has been implemented.

4. Initial Network Service

4.1 Network Survey Data

The datacomputer provides on-line storage and data management services for the Network SURVEY program that runs at MIT Project MAC. SURVEY attempts to do a complete ICP to the LOGGER socket of each host in the Arpanet at 20-minute intervals. It records the date, time, status and response time for each host and transmits the data to the datacomputer. If the datacomputer cannot accept the data, it is held temporarily at MIT for later transmission to the datacomputer. The retransmission occurs automatically.

Another program at MIT generates datalanguage for selective retrieval of the SURVEY data from the datacomputer.

Storage of the SURVEY data at the datacomputer on a regular basis began on July 10, 1973.

4.2 ETAC Weather Data

Plans are being made for storing a large file of weather data collected by the United States Air Force Environmental Technical Applications Center. In order to get operational experience with this data, two small files have been loaded using Version 0/9. One is the station library, which has information about the 12,000 weather stations that report regularly. The second file consists of one day's weather observations from the entire world.

These datacomputer files have been successfully accessed from CCA. ETAC will begin using them shortly.

4.3 DECtape FTP

Harvard University is using the datacomputer to extend its storage capacity. A user program running at Harvard transfers files between Harvard's disk and the datacomputer. Once on disk at Harvard, a file can be accessed by other programs there. A Harvard user can save his updated file by storing it again at the datacomputer. This facility allows users access to "off-line" files without manual intervention.

4.4 Utilization Statistics

The following chart indicates the number of times each Network site has connected to the datacomputer in the present reporting period since Version 0/9 was made available over the Arpanet.

	CCA	MIT-DMCG	PARC-MAXC	HARV	BBN-TENEX	TOTALS
WED 11-JUL-73	12	42	1			+55
THU 12-JUL-73	16	40				+56
FRI 13-JUL-73	56	80	1	14		+151
SAT 14-JUL-73	4	69	2			+75
SUN 15-JUL-73		45	1	6		+52
WEEK-TOTALS	88	276	5	20	0	389
MON 16-JUL-73	34	100	2			+136
TUE 17-JUL-73	7	50	1			+58
WED 18-JUL-73	5	55				+60
THU 19-JUL-73	45	62		6		+113
FRI 20-JUL-73	24	69			1	+94
SAT 21-JUL-73	1	76	1			+78
SUN 22-JUL-73	2	52			1	+55
WEEK-TOTALS	118	464	4	6	2	594
MON 23-JUL-73	15	74		21		+110
TUE 24-JUL-73	13	52		23		+88
WED 25-JUL-73	2	63		4		+69
THU 26-JUL-73	5	74		2		+81
FRI 27-JUL-73	13	60				+73
SAT 28-JUL-73	2					+2
SUN 29-JUL-73						+0
WEEK-TOTALS	50	323	0	50	0	423
MON 30-JUL-73	13	35				+48
TUE 31-JUL-73	25	17				+42
WEEK-TOTALS	38	52	0	0	0	90
MONTH-TOTALS	294	1115	9	76	2	1496
GRAND-TOTALS	294	1115	9	76	2	1496

5. Miscellaneous Activities

5.1 Seismic Data Working Group

Under the auspices of ARPA Nuclear Monitoring Research Office, a seismic data working group was formed on February 26, 1973 "to coordinate work in progress in planning the Seismic Data Acquisition, Processing, Analysis and Storage System required to support the ARPA Seismic Verification System".

Membership of the seismic data working group consists of CCA (data storage), BBN (data communication), and Teledyne Geotech (processing).

CCA accepted this responsibility as part of its present ARPA contract. During the present reporting period six meetings were held in Alexandria, Virginia at the Seismic Data Analysis Center.

CCA's contribution to these meetings was to discuss alternative ways in which large seismic data files collected from stations around the world could be stored centrally and disseminated to interested parties. Alternate technical approaches were presented, and cost figures were developed. CCA became acquainted with the data storage and dissemination problems of the seismic community.

5.2 Technical Presentations

Two major technical presentations on the datacomputer project were given during this reporting period. The first was at the EDUCOM Spring Conference, devoted to computer networks, at Harvard University on April 6, 1973. The second was at the National Security Agency, Ft. Meade, Md. on June 21, 1973.

Appendix
Version 0/9 Language Specifications

NIC 16446
NWG/RFC 515

R. Winter
Computer Corporation of America
09-Jun-73

Specifications for Datalanguage, Version 0/9

Preface

Datalanguage is the language processed by the Datacomputer, a data utility system being developed for the Arpanet. The Datacomputer performs data storage and data management functions for the benefit of computers on the network.

Version 0/9 is currently running at CCA. This version is extremely primitive; however, it does offer an opportunity for experience with the Datacomputer and with fundamental Datalanguage concepts.

Subsequent versions will provide greater portions of the full Datalanguage capability, which has been described earlier (Datalanguage, Working Paper No. 3, Datacomputer Project, October, 1971, NIC 8028). For example, one of the primary restrictions in 0/9--elementary data items must be fixed-length ASCII strings--will be eliminated in Version 0/10, which is currently being implemented.

Based on the experience gained in the implementation of these early versions, and based on the feedback from their use, a revised specification of the full language will be issued.

1. Introduction

This document presents a precise and complete specification of Datalanguage, Version 0/9. It is organized into 11 sections, of which this introduction is the first. Section 2 discusses the capabilities of Version 0/9 in general terms. Sections 3 and 4 are concerned with data description and the directory. Sections 5 through 8 cover the expression of data management operations. Section 9 discusses the recognition of names. Section 10 covers miscellaneous topics and Section 11 specifies the syntax in BNF.

This specification is to be followed with a user manual, which will present the language in tutorial form and treat components of the Datacomputer-user interface other than the language.

2. Capabilities of Version 0/9

Version 0/9 of Datalanguage has capabilities for the storage of files; for addition of data to existing files, and for the deletion of files. Retrievals can output whole files as well as subsets of files. Data can be selected from files by content, using expressions formed from boolean and inequality operators.

At the option of the file creator, an inversion is constructed and maintained by the Datacomputer. The inversion increases the efficiency of selective retrieval, at the cost of storage space and file maintenance effort. Users other than the file creator need not be aware of the existence of the inversion, or of which fields are inverted file keys. The language is designed so that they state the desired result of a retrieval, and the Datacomputer uses the inversion as much as the request permits.

Elementary data items are fixed-length ASCII strings. Files are a restricted class of hierarchical structures.

Many of the restrictions mentioned in this memo will be short-lived. In particular, those statements followed with 3 asterisks (***) refer to restrictions that will be considerably weakened or eliminated entirely in the next version of the software.

3. Data Description

A container is a variable whose value is a data object of general character and arbitrary size (in Version 0/9, size is restricted. See section 3.4). Examples of containers which are implemented in other systems are files, records, fields, groups, and entries.

The container is distinct from the data in the container. For example, space allocation is an operation on a container, while changing the unit price field from 25 to 50 is an operation on data in a container.

A container may enclose other containers. When a container is not enclosed by another container, it is said to be outermost. If container A encloses container B, and no other container in A also encloses B, then A immediately encloses B.

A Datalanguage description is a statement of the properties of a container.

All containers have the attributes ident and type. Ident is a character string by which users refer to the container. Type determines the form of the container's value; the value can be elementary, or it can consist of other containers. There are 3 types: LIST, STRUCT, and STRING(***). A LIST contains a group of containers having the same description. A STRUCT contains a group of containers, each of which has its own description. A STRING is a sequence of ASCII characters. While a STRING is not really an elementary item, it is handled as one in Version 0/9.

Certain containers can have other attributes. An outermost container has a function. The function attribute specifies whether the container is to be used for storage or for transmission.

Size is some meaningful dimension of the container, which is type-dependent. It is used for space allocation and data stream parsing.

An aggregate container (i.e., one that contains other containers) has as an attribute the description or descriptions of its components. Thus if S is a STRUCT containing A, B, and C, then the descriptions of A, B, and C are attributes of S.

A STRING defined in certain contexts can have an inversion attribute. This is an access property that is not really local to the STRING, but is associated with it for convenience.

3.1 Ident

The ident of a container is composed of alphanumeric characters, the first of which is alphabetic. It may not consist of more than 100 characters.

The elements of a STRUCT must have idents unique in the STRUCT.

3.2 Function

The function of a container is either FILE, PORT, or TEMPORARY PORT. When the function is FILE, then the container is used for storage of data at the Datacomputer. When the function is PORT, then the container is used for transmission of data into or out of the Datacomputer. When the function is TEMPORARY PORT (which may be abbreviated TEMP PORT), the container behaves like a PORT; however, its description is not retained in the Datacomputer beyond the session in which it is created.

3.3 Type

Type is one of: LIST, STRUCT, or STRING. These are defined on the preceding page.

In an occurrence of a STRUCT, the elements appear in the order in which their descriptions appear in the STRUCT description. All elements are present in each occurrence of the STRUCT.

An element of a STRUCT or LIST can be a container of any datatype. However, the outermost container must be a LIST(***).

3.4 Size

The size of a STRING is the number of characters in it. The size of a STRUCT is not defined (***). The meaning of the size of a LIST depends upon other properties of the LIST (***).

Ordinarily, the size of a LIST is the number of LIST-members. An exception is the case of the outermost-LIST. In an outermost-LIST with a function of FILE, the size is the number of LIST-members for which space should be allocated. When no size is present in this case, the system computes a default. In an outermost-LIST with a function of PORT, the size is ignored (***).

Only outermost containers may be larger than a TENEX page (2560 ASCII characters)(***).

3.5 Inversion

An inversion is an auxiliary data structure used to facilitate retrieval by content.

Its basic application is the fast retrieval of sets of outermost-LIST-members (this can be extended to other container sets, and will be after release 1). Consider a list of weather observations, stored as a file on the Datacomputer. If quick retrieval of observations by COUNTRY is desired, then this is

indicated in the description of the COUNTRY container. According to common usage in information retrieval, this makes COUNTRY a key in the retrieval of observations.

Note that the inversion option only affects the efficiency of retrieval by COUNTRY, not the ability to retrieve by COUNTRY.

There are restrictions on use of the inversion option. First, it can be applied only to STRINGs. Second a STRING having the inversion option must occur only once in each outermost-LIST-member. Third, it is ignored when applied to STRINGs in PORT descriptions.

Eventually there will be several types of inversion option; in Version 0/9 there is only the 'D' option (for distinct).

3.6 Syntax

The description is simply an enumeration of properties; these properties are specified in the order:

<ident> <function> <type> <size> <other>

Properties which do not apply are omitted.
An example:

```
F FILE LIST (25) A STR (10)
```

Here 'F' is the <ident>, 'FILE' is the <function>, 'LIST' is the <type>, '(25)' is the size, and 'A STR (10)' is the <other> of one description. Of course, 'A STR (10)' is itself another description: the description for members of the LIST named F.

An example of a complete description for a file of weather observations keyed on location:

```
WEATHER FILE LIST
      OBSERVATION STRUCT
            LOCATION STRUCT
                  CITY STR (10), I=D
                  COUNTRY STR (10), I=D
                  END
            TIME STRUCT
                  YEAR STR (2)
                  DAY STR (3)
                  HOUR STR (2)
                  END
            DATA STRUCT
                  TEMPERATURE STR (3)
                  RAINFALL STR (3)
                  HUMIDITY STR (2)
                  END
```

END

The ENDs are needed to delimit the list of elements of a STRUCT. ', I=D' indicates that the string is to be an inversion key for the retrieval of outermost-LIST-members.

4. Directory

The directory is a system file in which the names and descriptions of all user-defined containers are kept.

The directory is structured as a tree. Each node has an ident, which need not be unique. There is a single path from the root of the tree to any node. The idents of the nodes along this path are concatenated, separated by periods, to form a pathname, which unambiguously identifies the node (e.g., A.B.C could be a pathname for node with an ident of C).

In a later version of the software, the directory will be generalized to provide for links between nodes, so that it will not properly be a tree. For now, however, the tree model is convenient and adequate.

A node may represent a container, or it may simply hold a place in the space of pathnames. When it represents a container, it cannot (currently) have subordinate nodes.

Eventually, it is planned to model the directory as a structure of containers, with its description distributed throughout the structure. Most operations defined on the directory will be defined on user data, and vice versa. Access privileges and privacy locks will be part of the data description and will likewise be applicable both to directory nodes and data structures below the node level.

4.1 CREATE

A CREATE-request either: (a) adds a node to the directory, optionally associating the description of either a PORT or a FILE with the node, or (b) creates a temporary container which is not entered in the directory, but has a description and can be referenced in requests. If the description defines a file, CREATE causes space to be allocated for the file.

To create a node with a description:

```
CREATE <pathname> <description> ;
```

To create a node with no description:

```
CREATE <pathname> ;
```

Note that the description determines whether or not the container is temporary (see section 3.2 for details).

A CREATE-request adds a single node to the directory. Thus to add CCA.RAW.F to an empty directory, three requests are needed:

```
CREATE CCA ;
CREATE CCA.RAW ;
CREATE CCA.RAW.F ;
```

Notice that the last ident of the pathname doubles as the first ident of the description:

```
CREATE CCA.RAW.G FILE LIST A STR (5) ;
```

That is, G is both the ident of a node and the ident of an outermost container of type LIST.

4.2 Delete

A DELETE-request deletes a tree of nodes and any associated descriptions or data. The syntax is:

DELETE <pathname> ;

The named node and any subordinates are deleted.

Note that to delete data while retaining the directory entry and description, DELETE should not be used (see section 6.3 for the proper method).

4.3 LIST

The LIST-request is used to display system data of interest to a user. It causes the data specified to be transmitted through the Datalanguage output port.

Several arguments of LIST apply to the directory. LIST %ALL transmits all pathnames in the directory. LIST %ALL.%SOURCE transmits all descriptions in the directory. Instead of %ALL, a pathname can be used:

LIST <pn>.%ALL

Lists pathnames subordinate to <pn>.

LIST <pn>.%SOURCE

lists descriptions subordinate to the node represented by <pn>.

For details about the LIST-request, see section 10.1.

5. Opening and closing containers

Containers must be open before they can be operated on.

A container is open when it is first created. It remains open until closed explicitly by a CLOSE-request or implicitly by a DELETE-request or by session end.

A closed container is opened by an OPEN-request. A temporary container is always open; a CLOSE-request deletes it.

5.1 Modes

An open container has a mode, which is one of: READ, WRITE, or APPEND. The mode determines the meaning and/or legitimacy of certain operations on the container.

The mode is established by the operation which opens the container. It can be changed at any time by a MODE-request.

A CREATE leaves the container in WRITE mode. An OPEN either specifies the mode explicitly or implicitly sets the mode to READ.

5.2 Syntax

To open a container:
OPEN <pathname> <mode> ;
or:
OPEN <pathname> ;
where <mode> is defaulted to READ.

To close a container:
CLOSE <ident> ;
where <ident> is the name of an outermost container.

Two containers with the same outermost <ident> can not be opened at the same time (***).

To change the mode of an open container:
MODE <ident> <newmode> ;

5.3 LIST

LIST %OPEN transmits name, mode and connection status of each open outermost container through the Datalanguage output port. (The Datalanguage output port is the destination to which all Datacomputer diagnostics and replies are sent. It is established when the user initially connects to the Datacomputer.) For details of the LIST-request, see section 10.1.

6. Assignment

Assignment transfers data from one container to another.

The equal sign ('=') is the symbol for assignment. The value of the operand on the right of the equal sign is transferred to the operand on the left. (Eventually, both operands will be weakly-restricted Datalanguage expressions, which may evaluate to sets as well as to single containers. Now, the left must be a container name, the right may be a container name or a constant.)

Assignment is defined for all types of containers. When the containers are aggregates, their elements are paired and data is transferred between paired elements. Elements of the target container that do not pair with some source element are handled with a default operation (currently they are filled with blanks).

The operands of an assignment must have descriptions that match. The idea of matching is that the descriptions must be similar enough so that it is obvious how to map one into the other.

6.1 Conditions for legitimate assignment

Assignment must reference objects, not sets. An object is:

(a) an outermost container, or
(b) a constant, or
(c) in the body of a FOR-loop, either
  (c1) a member of a set defined by a FOR-OPERAND, or
  (c2) a container which occurs once in such a member

In the case of a reference of type (c1), the object referenced is taken to be the current member. In the case of (c2), the object referenced is that which occurs in the current member. This is explained further in section 7.

The left operand of an assignment is subject to further restriction. If it is an outermost container, it must be open in either WRITE- or APPEND-mode. If it is not an outermost container, then the reference is of type (c), which means that some FOR-operand has established a context in which the assign-operand is an object. The FOR-operand which establishes this context must be the output-operand of the FOR.

When the assign-operand is an outermost container, it must be open. Such an operand must be referenced by its simple container ident(***), not its directory pathname.

In the body of a loop nested in one or more other loops, assignments are further restricted, due to a 0/9 implementation problem. See section 7.2 for details.

Finally, the descriptions of the operands must match. If one is a constant, then the other must be a STRING(***). If both are containers, then in the expression:

A = B;

the descriptions of containers A and B match if:

1. A and B have the same type
2. if A and B are LISTs, then they have equal numbers of LIST-members, or else A is an outermost-LIST.
3. if A and B are aggregates, then at least one container immediately enclosed in A matches, and has the same ident as, one container immediately enclosed in B.

6.2 Result of assignment

If the operands are STRINGs, then the value of B, left-justified, replaces the value of A. If B is longer than A, the value is truncated. If B is shorter than A, then A is filled on the right with blanks as necessary.

If the operands are STRUCTs, then assignment is defined in terms of the STRUCT members. If a member of A, mA, matches and has the same name as a member of B, mB, then mB is assigned to mA. If no such mB exists, then mA is filled with blanks.

If the the operands are LISTs, the result depends on several factors. First, notice that the descriptions of the LIST-members must match; otherwise the assignment would not be legitimate by the matching rules of 6.1.

If A is an outermost-LIST, then it can be in either of two modes: WRITE or APPEND. If A is in WRITE-mode, its previous contents are first discarded; it is then handled as though it were in APPEND-mode.

If A is not an outermost-LIST, then it is always effectively in WRITE-mode.

After taking the mode of A into account, as described above, the procedure is:

for each member of LIST B
(a) add a new member to the end of A
(b) assign the current member of B to the new member of A

6.3 Deletion of Data Through Assignment

If A is an outermost container in WRITE-mode, and B is a container with description that matches A, and if B contains no data, then A=B has the effect of deleting all data from A. Note that if A is in APPEND-mode in these circumstances, then A=B is a no-operation (i.e., has no effect).

7. FOR

FOR <output set spec> , <input set spec> <body> END ;

The output set is optional: that is, FOR need not produce output. When the output set is omitted, the syntax is:

FOR <input set spec> <body> END ;

The operations specified in the body are performed once for each member of the input set. References in the body to the input set member are treated as references to the current input set member. When an output set is present, a new member is created and added to the output set for each iteration (i.e., for each input set member). References to the output set member, similarly, are treated as references to the current output set member.

The output set spec must be the name of a LIST member. Each iteration of the FOR will create one such member, and add it to its LIST (hereafter called the output LIST). The body determines the value that the new member receives. Any STRING in the new member which is not given a value by the body receives the default value of all blanks.

The input set spec must be an expression evaluating to a set of LIST-members (see section 7.1 for details of input set specification). Each iteration of the FOR will input one such member; the FOR will terminate when each member of the set has been processed. The LIST from which the input set members are drawn is called the input LIST.

FOR is effectively a means of accomplishing variants of assignment between a pair of LISTS. FOR is less concise than assignment, but offers more flexibility. Its advantages are:
(a) not all the input LIST-members need be transferred to the output LIST. A subset can be selected by content.
(b) the user has explicit control over the assignment of values to output LIST-members.

This is most easily understood by an example:

```
P PORT LIST                    F FILE LIST
  R STRUCT                       R STRUCT
    B STR                          A STRUCT
    C STR                            A1 STR
    END                              A2 STR
                                   B STR
                                   C STR
                                   END
```

```
(1)   P = F ;

(2)   FOR P.R, F.R
            P.R = F.R ;
            END ;

(3)   FOR P.R, F.R WITH A1 EQ 'XY' OR A2 GE 'AB'
            B = C ;
            C = A2 ;
            END ;
```

Here, (1) and (2) are entirely equivalent requests. However, (3) is quite different and is not expressible as assignment. It selects a subset of the F.Rs. The values it gives to the P.Rs could not result from application of the matching rules to F and P.

Because FOR is effectively assignment between a pair of LISTs, the LISTs referenced by a legitimate FOR-operation are largely subject to the same restrictions as LISTs referenced in an assignment. One exception is that the descriptions of the LIST-members need not match.

These restrictions are:
(a) both LISTs must be objects in the context in which the FOR appears.
(b) both LISTs must be open or contained in open outermost containers
(c) if the output LIST is an outermost container, it must be in WRITE- or APPEND-mode.
(d) If the ouput LIST is not outermost, the LIST which most immediately encloses it must be the output LIST of an enclosing FOR.

The mode of the output LIST of the FOR affects the result much as it would in an assignment: that is, a FOR outputting to a LIST in WRITE-mode overwrites previous contents, while a FOR outputting to a LIST in APPEND-mode adds to previous contents.

CAUTION TO THE READER: For convenience, these specifications use phrases such as 'LISTs referenced by a FOR'. Recall that such a phrase is not literally correct, in the sense that the operands of a FOR are always LIST members, not LISTs.

7.1 Details of input set specification

The input set is specified by a Datalanguage expression that evaluates to a set of LIST-members. Such an expression can be simply the set of all members of a LIST, or it can be a subset of the members of a LIST, specified by content. For example, with the description:

```
F FILE LIST
      R STRUCT
            A STR (1)
            B STR (1)
            END
```

the expression:

```
F.R
```

references all R's on the LIST F. However:

```
F.R WITH A EQ '5'
```

references only those R's containing an A having the value '5'. The expressions permitted as input set specifications are of the form:

<list-member-name> WITH <boolexp>

The <boolexp> is constructed of comparison expressions joined by the Boolean operatorsAND and OR. Any expression can be negated with NOT.

Comparison operators have the highest precedence. Next highest is AND, then OR, then NOT.

The comparison expressions are restricted to the form:

<container name> <comop> <constant>

where:

(a) <constant> is a string constant enclosed in single quotes (see section 10.2 for a discussion of constants)

(b) <comop> is one of six operators:

EQ	equal
NE	not equal
LT	less than
GT	greater than
LE	less than or equal to
GE	greater than or equal to

(c) <container name> is the name of a STRING that appears once in each LIST-member.

The constant is truncated or padded with blanks on the right to make it equal in size to the container to which it is being compared. Notice that padding on the right is not always desirable (users will have control over the padding in a future release). In particular, care must be excercised when using numbers in Version 0/9. (A number represented as a STRING should actually be described as a number; eventually it will be

possible to do this).

7.2 FOR-body

Two operations are legitimate in a FOR-body: FOR and assignment.

These are subject to the restrictions discussed in Section 6.1 and in the introduction to Section 7. The restrictions are related to three requirements: (1) that the names be recognizable (see Section 9 for details), (2) that a request be consistent regarding direction of data transfer between containers, both within itself and with the MODE of outermost containers, and (3) that transfers occur between objects, not sets of objects. The first two requirements are permanent, but will become weaker in later versions of the language. The last requirement is temporary and will be present only in early versions.

Due to an implementation problem associated with Version 0/9, there is a somewhat bizarre restriction applied to references made in the body of a loop nested in another loop. This restriction is not expected to pose any practical problems for users, and is not part of the language design, but is discussed here for completeness.

The restriction is most easily understood by example:

given the description

```
F LIST
      R STRUCT
            A STR (3)
            BL LIST (3)
                  B STR (3)
            C STR (3)
            END
```

and the request fragment:

```
FOR ...,R
      FOR ...,B
            ... = A ;
            ... = C ;
            END
      END
```

observe:

(a) The outer loop processes the set of R's in F.

(b) For each R in F, the inner loop processes the set of B's in the BL contained in that R.

(c) In the body of the inner loop, there are references to A and C, which do not occur in B, but do occur in R. That is, the objects referenced in the inner loop body are defined by the outer loop, not the inner loop. In general, this is fine; in the case of C, however, we have a problem.

(d) C occurs beyond the end of BL.
The 0/9 compiler is capable of neither (1) looking ahead enough to locate C before it compiles code for the loop, nor (2) while generating code to loop on the B's in BL, generating a separate body of code that skips to the end of BL to locate C. Thus it can handle A, which has been located before it begins loop generation, but it cannot handle C, which requires a little foresight.

The request fragment shown would not cause problems if the description were changed to:

```
F LIST
      R STRUCT
            A STR (3)
            C STR (3)
            BL LIST (3)
                  B STR (3)
            END
```

Then both A and C would have been found before code for the inner loop was generated.

8. Data Transmission

Data is transferred from container to container by execution of assignment and FOR operations. The outermost containers involved in transfers can be files or ports. If both are files, then the transfer is internal to the Datacomputer. If either is a port, then an address in the external world is needed to accomplish the data transmission.

Such an address is supplied through a CONNECT-request, which associates a container (having a function of PORT) with an external address:

CONNECT <ident> TO <address> ;

Here <address> is either a specification of host and socket number, or a TENEX file designator (for CCA's TENEX) enclosed in single quotes. The host and socket form is:

<socket> AT <host>

where <socket> is a decimal number, and host is either a decimal number or a standard host name (since standard host names don't exist right now, it has to be the TENEX 'standard' name for the host. Contact the author for the latest list.) If <host> is omitted, it is taken to be the host from which the Datalanguage is being transmitted.

The address associated with a port can be changed by issuing another CONNECT-request.

A DISCONNECT-request simply breaks an existing port/address association without establishing a new one. (A CLOSE-request that references an open port executes a DISCONNECT.) The syntax of DISCONNECT is:

DISCONNECT <ident> ;

A port is disconnected when: (a) no successful CONNECT-request has ever been issued for it, or (b) a DISCONNECT for the port has been executed since the last successful CONNECT.

When a disconnected port is referenced in an assignment, it is connected by default either to:

(a) the connection used for the transmission of Datalangauage to the Datacomputer, or
(b) the connection used for the transmission of Datacomputer diagnostics to the user

The choice between (a) and (b), of course, depends on whether the reference is for input or output. These connections are established by the network user's ICP to the Datacomputer at the beginning of the session.

Note that CONNECT and DISCONNECT do not open files or network connections. They simply make address associations within the Datacomputer. The files and connections are opened before each request and closed after each request.

9. Names in Datalanguage

A name is recognized when it has been associated with a particular data container or set of containers.

Datalanguage has mechanisms for the recognition of names in contexts. That is, the meaning of the name is related to where it appears.

This makes it possible to attach natural meanings to partially qualified names.

For example:

```
WEATHER FILE LIST
      STATION STRUCT
            CITY STR (15)
            STATE STR (15)
            DATA LIST (24)
                  OBSERVATION STRUCT
                        HOUR STR (2)
                        TEMPERATURE STR (3)
                        HUMIDITY STR (2)
                        PRESSURE STR (4)
                        END
            END

RESULTS PORT LIST
      RESULT STRUCT
            CITY STR (15)
            HOUR STR (2)
            TEMPERATURE STR (3)
            END

FOR STATION WITH STATE EQ 'CALIFORNIA'
      FOR RESULT, OBSERVATION WITH HOUR GT '12'
                  AND HUMIDITY LT '75'
            CITY = CITY ;
            HOUR = HOUR ;
            TEMPERATURE = TEMPERATURE ;
            END ;
      END ;
```

in the assignment 'CITY = CITY', the first CITY is understood to be RESULT.CITY and the second is understood to be STATION.CITY.

9.1 Informal Presentation of Recognition Rules

'Ident' is used in the sense of section 3. For example, in the description:

```
. FILE LIST R STRUCT A STR (1) B STR (1) END
```

F, R, A and B are idents.

A context is a tree whose nodes are idents. In such a tree, the terminal nodes are idents of STRINGs. The ident of a LIST is superior to the ident of the LIST-member. The ident of a STRUCT is superior to the idents of the STRUCT elements. The context whose top node is F is said to be the context of F.

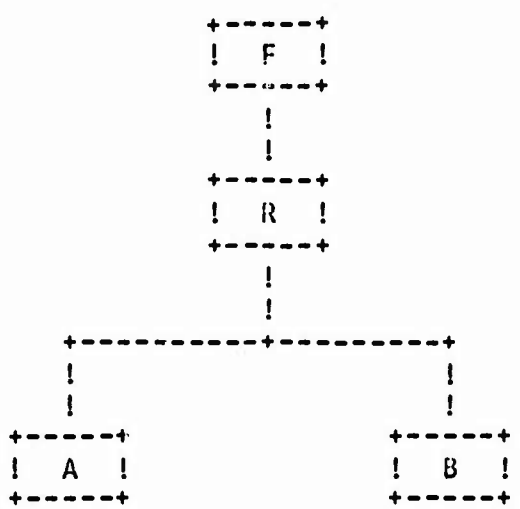

Figure 9.1-1 The context of F

A pathname is a sequence of idents, naming nodes along a path from one node to another. A full pathname in the context starts at the topmost node. Thus F.R.B is a full pathname in the context of F. A partial pathname starts at a node other than the topmost node (e.g. R.B, B).

In Datalanguage, pathnames omitting intermediate nodes, such as F.B (which omits 'R'), are not permitted. Thus partial pathnames are partial only in that additional names are implied on the left.

Three attempts at recognition of a pathname, PN, in a context, CX, are made:

(a) recognition of PN as a full pathname in CX
(b) recognition of PN as a partial pathname in which only the topmost node of CX is omitted
(c) recognition of PN as an arbitrary partial pathname occurring only once in CX.

The attempts are made in the above order, and the recognition process halts with the first successful attempt.

As an example, consider the description:

```
F FILE LIST
      R STRUCT
            A STR
            B STR
            S STRUCT
                  R STR
```

which defines the context in Figure 9.1-2.

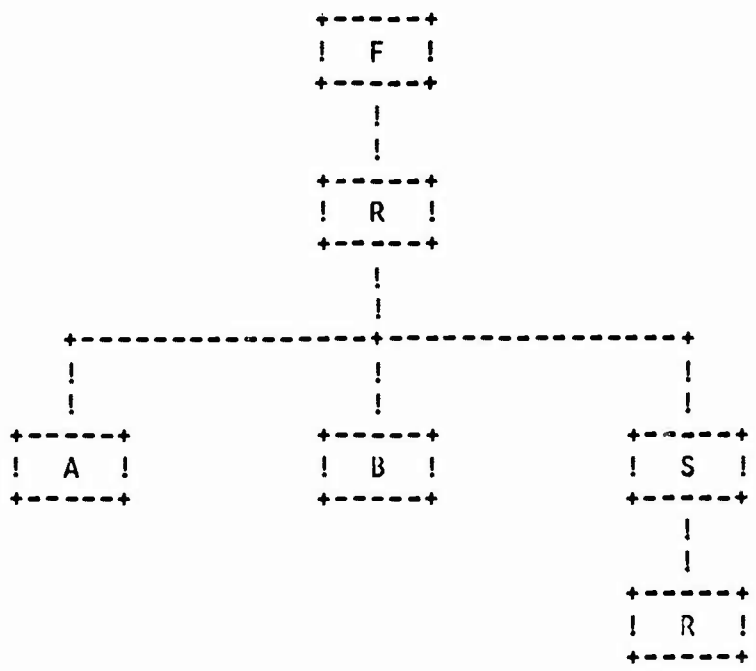

Figure 9.1-2 Example Context

In this context, F.R.A is a full pathname. Thus, F.R.A is recognized in attempt (a). R is a partial pathname in which only the topmost node is omitted. Thus R is recognized in attempt (b). Note carefully that R is recognized as a reference to F.R, not to F.R.S.R. Finally, B is an arbitrary partial pathname occurring only once in the context. Thus B is recognized in attempt (c).

Two stacks of contexts are maintained: one for names used in an input sense, and one for names used in an output sense. When a name is to be recognized, it is first decided whether the reference is an input reference or an output reference. An

input reference is (a) the right hand operand of an assign, or (b) a name in the input set spec of a FOR. An output reference is (a) the left operand of an assign, or (b) the output operand of a FOR. The first context on the appropriate context stack is then searched, according to the procedure outlined on the previous page. If the name is neither recognized nor ambiguous in that context, search continues in the next context on the stack. If the name can be recognized in none of the contexts on the appropriate stack, it is unrecognizable.

When a stack is empty, the recognition procedure is different. The search is carried on in a special context: the context of %OPEN. Its top node, %OPEN, is a built in system ident. Subordinate to %OPEN is a context for each open directory node. Each such context represents all the idents defined in the associated data description. Thus, if there were two open directory nodes having data descriptions:

```
F FILE LIST R STRUCT A STR (1) B STR (1)
```

and:

```
P PORT LIST R STRUCT A STR (1) B STR (1)
```

then the context of %OPEN would be as in Figure 9.1-3.

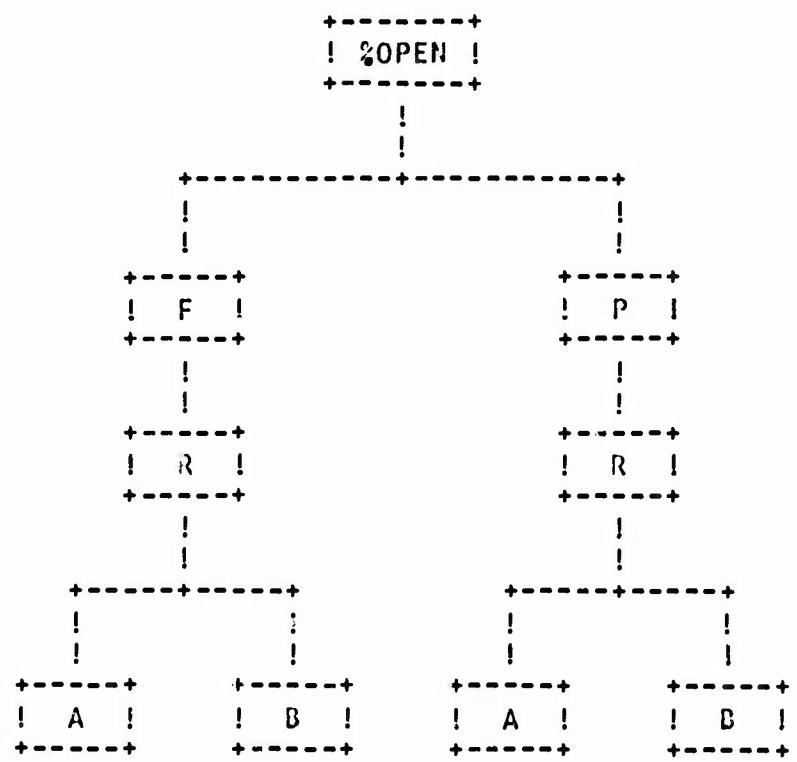

Figure 9.1-3 The context of %OPEN

When a directory node is closed, the corresponding context is removed from the context of %OPEN. When a node is opened, the associated context is added as the rightmost context subordinate to %OPEN.

9.2 Context Stack Maintenance

The context stacks are always empty between requests. The FOR-operator adds entries to the stacks. FOR A adds the context of A to the input context stack. FOR A, B ... adds the context of A to the output stack and the context of B to the input stack.

When adding to an empty stack, FOR adds two contexts instead of one. The second addition to the stack is the context of the looparg; the first addition is the context of the outermost container which encloses the looparg.

For example, given a context of %OPEN as in Figure 9.1-3, and empty context stacks, the fragment 'FOR F.R ...' adds two contexts: (1) the context of F, and (2) the context of F.R.

Contexts are removed from the stacks by the END matching the FOR which added them.

10. Miscellaneous Topics

10.1 The LIST-request

The LIST-request provides a means for the user to inspect system data of interest to him. The user can determine the contents of the directory, the source or parsed form of any data description in the system, and the mode and connection status of any open file or port.

The LIST operator has a single operand, which can have any of several forms. The action of the operator is to output a list of values on the Datalangauge output port.

To output a list of pathnames, the operand used is '%ALL'. When '%ALL' appears alone, all pathnames in the directory are listed. When '.%ALL' appears after the last ident in a directory pathname, the full pathnames of all nodes subordinate to the named node are listed.

To determine the status of the open files and ports, the operand '%OPEN' is used. It outputs directory pathname, mode and connection status.

To output one or more source descriptions, the operand '.%SOURCE' is used. '.%SOURCE' is preceded with one of (a) '%ALL', (b) '%OPEN', or (c) the ident of an open outermost container. The output is either (a) all descriptions, (b) all open descriptions, or (c) a particular open description.

To output a parsed description, the operand '.%DESC' is used ('%DESCRIPTION' is also accepted). This operand is preceded either with (a) '%OPEN', or (b) the ident of an open outermost container.

Examples:

Let P be the ident of an open PORT. Let A.B.C be a directory pathname.

```
LIST %ALL
LIST A.B.C.%ALL
LIST %OPEN
LIST %ALL.%SOURCE
LIST %OPEN.%SOURCE
LIST P.%SOURCE
LIST %OPEN.%DESC
LIST P.%DESC
```

Note that 'LIST A.B.C.%SOURCE' is not legal -- '.%SOURCE' must be preceded with the ident of an open container, not a pathname. A similar restriction applies to '.%DESC'.

10.2 Constants in Datalanguage

A constant of type STRING can be included in a Datalanguage request by enclosing it in single quotes:

```
'ABC'
```

A single quote is included in a constant by preceding it with a double quote:

```
'FATHER"'S'
```

Likewise, a double quote is included by preceding it with a double quote:

```
'JOHN SAID ""HELLO""'
```

Such constants can be used on the right of comparison operators and of assignment operators which reference strings.

Eventually, Datalanguage will contain facilities for the inclusion of constants of all datatypes; such constants are simply a special case of the Datalanguage expression and will be permitted wherever such expressions are permitted.

10.3 Character Set

Internally, Version 0/9 of the Datacomputer software operates in 7-bit ASCII characters. Its output to the ARPANET is converted to 8-bit ASCII. On input from the ARPANET, it expects 8-bit characters, which it converts to 7-bit characters.

To convert from 7- to 8-bit characters, a '0' bit is prefixed. To convert from 8- to 7-bit characters, the high-order bit is checked. If the high-order bit is a '0', the bit is discarded and the character is accepted as a 7-bit character. If the high-order bit is a '1', then the character is discarded.

(In the following discussion, as elsewhere in this memo, all references to numerical character codes are in decimal).

The remainder of this section discusses treatment of codes 0 through 127, when they appear in Datalanguage requests.

In general, printing characters are acceptable in requests, while control characters are not. There are some exceptions, which are detailed below. The printing characters are codes 32-126. The control characters are codes 0-31 and 127.

Certain control characters are accepted:

Tab(9) is accepted freely in requests. It functions as a separator (explained below).

EOL(31), meaning end-of-line, is accepted in requests, functioning both as a separator and an activator (a). EOL has a special meaning in data, and should not be introduced

into STRING constants(***).

Control-L(12) is an activator and a high-level request delimiter. It terminates the text of any request being processed when it is encountered in the input stream. It is useful in Datacomputer-user program synchronization.

Control-Z(26) means end-of-session when encountered in Datalanguage. It has the properties of control-L, and in addition, causes the Datacomputer to execute an end-of-session procedure, which results in closing the Datalanguage connections, closing any open files or ports, etc. The effect is equivalent to a LOGOUT(which does not exist yet).

The two-character sequence <carriage return(13), line feed(10)> is equivalent to EOL (and is translated to EOL on input from the network). The reverse sequence, as well as either character alone, is treated simply as other control characters (ignored).

All other control characters are ignored.

The printing characters are further divided into four groups: special characters, upper case letters, lower case letters, and digits (the membership of these groups is defined in section 11).

Corresponding upper and lower case letters are equivalent in requests, except within quoted strings.

Certain special characters have a lexical function, which is either break or separator. A break character terminates the current lexical item and returns itself as the next item. A separator character terminates the current item but does not begin a new item (i.e., its only function is to separate items). Multiple separators are equivalent to a single separator. A separator can always be inserted before or after a break character, without altering the meaning of the request.

The separators are tab(9), space(32), and end-of-line(31).

The break characters are left parenthesis(40), right parenthesis(41), equals(61), semicolon(59), period(46), comma(44), quote(39), and slash(47).

(a) An activator character causes the Datacomputer to process whatever has been received since the previous activator or the beginning of the request. The meaning of a request is independent of the presence/absence of activators. However, a request will not be executed until an activator beyond the end of the request is received.

While Version 0/9 defines (carriage return, linefeed) in terms of EOL, network users should not think in terms of sending EOL's to the Datacomputer over the network. EOL is not part of the network ASCII character set, and has no definite permanent place in Datacomputer implementation plans.

10.4 Comments

Comments can be included in Datalanguage requests. A comment is begun with the two-character sequence '/*', and ended with the two-character sequence '*/'. Since slash is a break character, a comment does cause a lexical break; its overall effect is that of a separator.

10.5 Reserved Identifiers

Certain identifiers are reserved in Datalanguage, and should not be used to name containers or directory nodes. These are:

AND
APPEND
AT
CLOSE
CONNECT
CREATE
DELETE
DISCONNECT
END
EQ
FILE
FOR
GE
GT
LE
LIST
LT
MODE
NE
NOT
OPEN
OR
PORT
READ
STR
STRUCT
TO
WITH
WRITE

More reserved identifiers will be added in Version 0/10.

11. Datalanguage Syntax Expressed in BNF

11.1 Requests

11.1.01 <request> ::= ;

11.1.02 <request> ::= <create> ;

11.1.03 <request> ::= OPEN <pn> ;

11.1.04 <request> ::= OPEN <pn> <mode> ;

11.1.05 <request> ::= CLOSE <ident> ;

11.1.06 <request> ::= CONNECT <ident> TO <address> ;

11.1.07 <request> ::= DISCONNECT <ident> ;

11.1.08 <request> ::= MODE <ident> <mode> ;

11.1.09 <request> ::= DELETE <pn> ;

11.1.10 <request> ::= LIST <listarg> ;

11.1.11 <request> ::= <sr-request> ;

11.2 Data Description and Creation

11.2.01 <create> ::= CREATE <pn>

11.2.02 <create> ::= CREATE <pn> <ftn> LIST <desc>

11.2.03 <create> ::= CREATE <pn> <ftn> LIST <size> <desc>

11.2.04 <desc> ::= <ident> <attributes>

11.2.05 <attributes> ::= LIST <size> <desc>

11.2.06 <attributes> ::= STRUCT <descs> END

11.2.07 <attributes> ::= STR <size>

11.2.08 <attributes> ::= STR <size> ,I=D

11.2.09 <descs> ::= <desc>

11.2.10 <descs> ::= <descs> <desc>

11.2.11 <ftn> ::= PORT

11.2.12 <ftn> ::= FILE

11.2.13 <ftn> ::= TEMP PORT

11.2.14 <ftn> ::= TEMPORARY PORT

11.2.15 <size> ::= (<integer constant>)

11.3 Data Storage and Retrieval

11.3.01 <sr-request> ::= <assign>

11.3.02 <sr-request> ::= <loop>

11.3.03 <assign> ::= <pn> = <object>

11.3.04 <loop> ::= FOR <looparg> <loopbody> END

11.3.05 <looparg> ::= <exp>

11.3.06 <looparg> ::= <pn> , <exp>

11.3.07 <loopbody> ::= <sr-request>

11.3.08 <loopbody> ::= <loopbody1> <sr-request>

11.3.09 <loopbody> ::= <loopbody1>

11.3.10 <loopbody1> ::= <sr-request> ;

11.3.11 <loopbody1> ::= <loopbody1> <sr-request> ;

11.4 Expressions

11.4.01 <exp> ::= <pn>

11.4.02 <exp> ::= <pn> WITH <boolexp>

11.4.03 <boolexp> ::= <pn> <comop> <string constant>

11.4.04 <boolexp> ::= (<boolexp>)

11.4.05 <boolexp> ::= NOT <boolexp>

11.4.06 <boolexp> ::= <boolexp> AND <boolexp>

11.4.07 <boolexp> ::= <boolexp> OR <boolexp>

11.4.08 <comop> ::= EQ

11.4.09 <comop> ::= NE

11.4.10 <comop> ::= GT

11.4.11 <comop> ::= LT

11.4.12 <comop> ::= GE

11.4.13 <comop> ::= LE

11.5 Miscellaneous

11.5.01 <address> ::= <quote> <TENEX file designator> <quote>

11.5.02 <address> ::= <socket> AT <host>

11.5.03 <address> ::= <socket>

11.5.04 <socket> :: = <integer constant> //INTERPRETED AS DECIMAL

11.5.05 <host> ::= <integer constant> //INTERPRETED AS DECIMAL

11.5.06 <host> ::= ***** TENEX host names *****

11.5.07 <object> ::= <pn>

11.5.08 <object> ::= <string constant>

11.5.09 <mode> ::= READ

11.5.10 <mode> ::= APPEND

11.5.11 <mode> ::= WRITE

11.5.12 <listarg> ::= %ALL

11.5.13 <listarg> ::= <pn> . %ALL

11.5.14 <listarg> ::= %OPEN

11.5.15 <listarg> ::= %ALL . %SOURCE

11.5.16 <LISTARG> ::= <IDENT> . %SOURCE

11.5.17 <listarg> ::= %OPEN . %SOURCE

11.5.18 <listarg> ::= %OPEN . %DESC

11.5.19 <listarg> ::= <ident> . %DESC

11.5.20 <pn> ::= <ident>

11.5.21 <pn> ::= <pn>.<ident>

11.5.22 <ident> ::= <letter>

11.5.23 <ident> ::= <ident> <letter>

11.5.24 <ident> ::= <ident> <digit>

11.5.25 <integer constant> ::= <digit>

11.5.26 <integer constant> ::= <integer constant> <digit>

11.5.27 <string constant> ::= <quote> <string conbody>
<quote>

11.5.28 <string conbody> ::= <nonquote>

11.5.29 <string conbody> ::= <string conbody> <nonquote>

11.6 Character Set

11.6.01 <separator> ::= //SPACE(32)

11.6.02 <separator> ::= //TAB(9)

11.6.03 <separator> ::= <eol>

11.6.04 <special> ::= <quote>

11.6.05 <special> ::= <superquote>

11.6.06 <special> ::= <special1>

11.6.07 <letter> ::= A

11.6.08 <letter> ::= B

.....

11.6.09 <letter> ::= Z

11.6.10 <letter> ::= a

11.6.11 <letter> ::= b

.....

11.6.12 <letter> ::= z

11.6.13 <digit> ::= 0

11.6.14 <digit> ::= 1

.....

11.6.15 <digit> ::= 9

11.6.16 <nonquote> ::= <letter>

11.6.17 <nonquote> ::= <digit>

11.6.18 <nonquote> ::= <superquote> <quote>

11.6.19 <nonquote> ::= <superquote> <superquote>

11.6.20 <nonquote> ::= <special1>

11.6.21 <nonquote> ::= <separator>

11.6.22 <eol> ::= //EOL (31)

11.6.23 <eol> ::= <carriage return> <line feed>

11.6.24 <carriage return> ::= //CARRIAGE RETURN (13)

11.6.25 <line feed> ::= //LINE FEED (10)

11.6.26 <quote> ::= ' //SINGLE QUOTE(44)

11.6.27 <superquote> ::= " //DOUBLE QUOTE(34)

11.6.28 <special1> ::= ! //EXCLAMATION POINT(33)

11.6.29 <special1> ::= # //NUMBER SIGN(35)

11.6.30 <special1> ::= $ //DOLLAR SIGN(36)

11.6.31 <special1> ::= % //PERCENT SIGN(37)

11.6.32 <special1> ::= & //AMPERSAND(38)

11.6.33 <special1> ::= (//LEFT PARENTHESIS(40)

11.6.34 <special1> ::=) //RIGHT PARENTHESIS(41)

11.6.35 <special1> ::= * //ASTERISK(42)

11.6.36 <SPECIAL1> ::= + //PLUS SIGN(43)

11.6.37 <special1> ::= , //COMMA(44)

11.6.38 <special1> ::= - //MINUS SIGN(45)

11.6.39 <special1> ::= . //PERIOD(46)

11.6.40 <special1> ::= / //SLASH(47)

11.6.41 <special1> ::= : //COLON(58)

11.6.42 <special1> ::= ; //SEMICOLON(59)

11.6.43 <special1> ::= < //LEFT ANGLE BRACKET(60)

11.6.44 <special1> ::= = //EQUAL SIGN(61)

11.6.45 <special1> ::= > //RIGHT ANGLE BRACKET(62)

11.6.46 <special1> ::= ? //QUESTION MARK(63)

11.6.47 <special1> ::= @ //AT-SIGN(64)

11.6.48 <special1> ::= [//LEFT SQUARE BRACKET(91)

11.6.49 <special1> ::= \ //BACK SLASH(92)

11.6.50 <special1> ::=] //RIGHT SQUARE BRACKET(93)

11.6.51 <special1> ::= ^ //CIRCUMFLEX(94)

11.6.52 <special1> ::= _ //UNDERBAR(95)

11.6.53 <specail1> ::= ` //ACCENT GRAVE(96)

11.6.54 <special1> ::= { //LEFT BRACE(123)

11.6.55 <special1> ::= | //VERTICAL BAR(124)

11.6.56 <special1> ::= } //RIGHT BRACE(125)

11.6.57 <special1> ::= ~ //TILDE(126)